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XIX. *On the manufacture of the sulphate of magnesia at Monte della Guardia, near Genoa.* By H. Holland, M. D. F.R. S.

Read June 13, 1816.

THE following account, which I have the honour to present to the Royal Society, of the manufacture of sulphate of magnesia at Monte della Guardia, near Genoa, has been drawn up chiefly from the note I made, when visiting this spot, in the spring of 1815. These notes have received additions from a paper, drawn up in 1803, by my friend Signore G. MOJON, lecturer on chemistry at the college of Genoa, who has bestowed much attention on the subject, and made several experiments on the composition and comparative purity of the manufactured salt.\*

The Monte della Guardia, situated eight miles to the N. west of the city of Genoa, is one of the higher points in that part of the chain of the Ligurian Appenines, which borders immediately on the coast. The mountains in this portion of the chain are chiefly of primitive slate, with some subordinate formations of marble and serpentine, a considerable extent of transition and secondary limestone, chiefly to the eastward of Genoa, and a few more partial deposits of sandstone and coal.

The summit of Monte della Guardia is somewhat more than 2000 feet above the level of the sea, from which it is five

\* This paper was published by the Society of Medical Emulation in Genoa.

miles distant. The ascent towards the mountain from Sestri, the nearest point on the coast, is uniform, though rugged; following the course of the rapid torrent, called the Panigaro. The ravine of this torrent is interesting, inasmuch as it forms the division between a high ridge of serpentine, which occurs on its eastern side; and an insulated formation of magnesian limestone, which composes the hill of Monte del Gazzo, to the north of Sestri, and other adjacent heights on the western side of the stream. This magnesian limestone, which in Monte del Gazzo reaches a height of more than 1200 feet, forms in various places naked cliffs, distinctly showing the stratification of the rock; which stratification, as well as the colour of the limestone, is very remarkably contrasted with the character of the serpentine rocks, on the opposite side of the ravine.

The latter, together with some argillaceous and chlorite slate of the same formation, compose for several miles, the ridge of hills between the torrent of Panigaro, and the broader valley of the Polcevera to the east; stretching upwards in a direct line from the sea towards the summit of Monte della Guardia. The primitive schistus is doubtless the base of this formation; the serpentine reposes upon it in vast unconformable masses; exhibiting a surface of great ruggedness, and almost entirely bare of vegetation; with the dark green colour, and usual resinous lustre of this mineral. I observed much steatite, talc, and asbestos in it; also many small veins of pyrites. The asbestos of this place affords numerous fine specimens to the cabinets of Genoa.

Monte della Guardia may be considered the summit of this ridge. It exposes to the south a somewhat concave outline;

the front of which is deeply worn out, so as to show the stratification of the primitive slate, mixed with chlorite slate, with the other magnesian minerals just noticed, and with numerous veins, or layers of copper and iron pyrites. The specimens of this pyrites have a steel grey, or greenish yellow colour, according to the respective predominance of iron or copper. The whole substance of the pyrites has a schistose structure, corresponding with that of the rocks in which it is situated. It is so intimately mixed with the same magnesian minerals, as to be for the most part extremely unctuous to the touch. It is in general easily sectile. The specific gravity varies from 3.6 to 4.6.

It is on this side of the Monte della Guardia, and from the materials just described, together with the magnesian limestone of Monte del Gazzo, that the manufacture of sulphate of magnesia has been established; it is at present carried forward on a small scale, but is evidently capable of extension and improvement. The original object of attention in this place was the working of the copper and iron pyrites; but the observation of the crystals of sulphate of magnesia, formed during the processes applied to these ores, changed in great degree the character of the manufacture; and the green vitriol and copper obtained here are now become secondary objects to the proprietors. The process employed for the formation and separation of the sulphate of magnesia is briefly as follows: the pyrites is worked out of the mountain by tunnels, which the steep natural section of its front, and the general direction of the veins, allow to be carried nearly on an horizontal level. Some of these galleries, which I saw, were more than 200 feet in length, and varying from 10 to 15 feet

in width. Others, which are now filled with water, or destroyed by the crumbling down of the rock, were described to me as of still greater length. The ore, thus obtained, is broken down into small pieces, and roasted in an open pit, or kiln, about 20 feet in depth; with the alternation of wood, so disposed as most effectually to aid the combustion. This process of roasting continues generally for ten days. The kiln being sufficiently cooled, the ore is removed thence, and disposed in large heaps, underneath a shed in the vicinity. Here it remains for several months fully exposed to the air, and occasionally moistened with water thrown upon it, to aid the chemical changes by which the salt is found. An efflorescence of sulphate of magnesia soon commences, and gradually proceeds, so as to cover with minute crystals the surface of the ore, which, during this time, crumbles down into very small fragments.

This is the usual commencement of the process, but there are varieties of the ore, more easily decomposable, which require less roasting, or may even be submitted to the after processes, without any application of heat. Other varieties, on the contrary, require more roasting, to prepare them for the proper efflorescence of the salt, which efflorescence itself varies in rapidity, according to the particular description of the ore.

The materials, brought into this strata, are then lixiviated; and the liquor containing in solution the sulphates of magnesia, of copper, and of iron, is filtered; in passing it through layers of sand and straw, disposed in large wooden vessels. These processes repeated as often as may be necessary, the next object is the separation from the liquor, of the metallic

sulphates. When the sulphate of copper is perceived to be abundant, the metal is precipitated by refuse of iron, introduced into the liquor. The sulphate of iron, and any remaining sulphate of copper, are decomposed by the addition of lime, in the state of milk of lime, which causes a precipitate of sulphate of lime, together with the metallic oxides.

The lime employed for this decomposition, is obtained from the magnesian limestone, already described as belonging to this district. That of Monte del Gazzo is preferred, both as nearer to the spot, and possibly from its containing a larger proportion of magnesia, than the other magnesian limestones of this coast, about 16 per cent., as appears from analysis made of it. It appears probable, that a certain portion of sulphate of magnesia is obtained from the use of this limestone, in decomposing the metallic salts, and the process of manufacture thereby rendered somewhat more productive. The quantity of lime employed may equal about  $\frac{1}{100}$  part of the weight of the pyritic ore.

The metals being thus separated from the saline liquor, it is filtered anew, and then evaporated to a certain point in a large copper boiler. It is subsequently let off into small glazed earthen vessels where the crystallization of the salt takes place. M. MOJON mentions the circumstance of its being needful frequently to disturb the crystallization, to satisfy the prejudice of the purchasers, who consider it essential that the salt should be delivered to them in the form of small spicular crystals.

The produce of sulphate of magnesia varies of course according to the quality of the ore. In general, perhaps, it may be stated at  $\frac{1}{10}$  of the weight of the material employed. The

ore remaining after the first filtration, is usually roasted and lixiviated a second time, to obtain the portion of salt which it is still capable of affording.

It is almost unnecessary to make any remarks on the theory of the process just described. The sulphuric acid, formed by the action of heat, air, and water upon the pyritic ore, combines with the metals, and with the magnesian earth, which the ore contains. I am not aware of any experiments that have been made, to ascertain the proportion of salt which may be derived from the use of the magnesian limestone. Probably, however, it is extremely small; and it would seem very doubtful, from the nature of the process, whether any improvement to the manufacture can be expected from this source. The effect of employing more of the limestone than is strictly necessary, would be, that the lime, rather than the magnesia, would unite with the sulphuric acid; and if the addition of the mixed earth were in excess, the lime alone would have effect in the decomposition; and sulphate of lime, with the metallic oxides, would be the new products obtained.

M. MOJON has proposed a variation in the manufacture at Monte della Guardia; depending on the different tendency of the sulphate of magnesia, and of the metallic sulphates towards crystallization. The principal object of the variation would be to save the sulphate of iron, now lost by decomposition; and to increase the value of the produce of copper by obtaining it in the state of sulphate. This change in the process has not hitherto been adopted; and probably might be found to be attended with several difficulties in practice.

The buildings connected with the establishment at Monte  
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della Guardia, are on a small scale ; their situation is a singular one, at the height of 1600 feet above the level of the sea. The present conductor, and, as I believe, the chief proprietor of the establishment, is Signore ANSALDO of Sestri, a man of intelligence and activity.

The produce of the sulphate of magnesia, as far as I could ascertain from enquiries on the spot, does not at present exceed  $1\frac{1}{2}$  cwt. per week. It might doubtless be increased to a much larger amount, from the abundance of the materials of manufacture. The colour and general appearance of the salt are good, and M. MOJON has found it by analysis to be a very pure sulphate of magnesia. It is used pretty extensively in the medical practice of Italy, under the name of the *Sal Inglese* ; and might, in the extension of the manufacture, become an article of very considerable profit to the proprietors of the establishment.

Before concluding this paper, I may add, that I have been informed of an analysis by VAUQUELIN of the pyritic ore of the Monte della Guardia ; but, from the want of sufficient references, I have hitherto been unable to ascertain the results of this examination.